Do's and Don’ts for Hospital Cleaning
Prof. Stephanie Dancer, NHS Scotland & Edinburgh Napier University
The A. Denver Russell Memorial Teleclass Lecture

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Hosted by Prof. Jean-Yves Maillard
Cardiff University, Wales

How should we approach control of antimicrobial resistance?

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Antimicrobial stewardship?

Antimicrobial drugs might be encouraging resistance...

...but patients acquire resistant pathogens from the contaminated near-patient environment

So controlling AMR requires attention on:

i) vertical (direct) effects by antimicrobial drugs

ii) horizontal (indirect) spread caused by infection prevention & control deficits


Why are we still debating the value of cleaning?

- Invisible
- Aesthetic bias
- Pathogen detection
- Evidence-based science?
- No accepted measure
- Womens’ work
- Fabric deficits
- Costly
  - Low paid; low status; and dirty

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Properties of hospital pathogens

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Survival time</th>
<th>Infectious dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>7 days to &gt;7 months</td>
<td>4 cfu’s</td>
</tr>
<tr>
<td>Acinetobacter</td>
<td>3 days to &gt;5 months</td>
<td>250 cfu’s</td>
</tr>
<tr>
<td>C. difficile</td>
<td>&gt;5 months</td>
<td>5 spores</td>
</tr>
<tr>
<td>VRE</td>
<td>5 days to &gt;4 months</td>
<td>&lt;10^3 cfu’s</td>
</tr>
<tr>
<td>E. coli</td>
<td>2 hrs to 16 months</td>
<td>10^2-10^6 cfu’s</td>
</tr>
<tr>
<td>Klebsiella</td>
<td>2 hrs to &gt;30 months</td>
<td>10^3 cfu’s</td>
</tr>
<tr>
<td>Norovirus</td>
<td>8 hrs to 7 days</td>
<td>&lt;20 virions</td>
</tr>
</tbody>
</table>

*Kramer, BMC Infect Dis, 2006; Dancer SJ, Clin Microbiol Rev 2014*

Increased risk associated with the prior room occupant.
The figures of difference in risk are unadjusted based on raw data.

*Is risk related to environmental longevity?* Otter et al, Am J Infect Control 2013
Mitchell et al, J Hosp Infect 2015
Where are the pathogens in a hospital?

Hayden et al, SHEA 2004

Figure showing an association between hand touch frequency and gross microbial soil for five ICU sites

Adams et al, J Hosp Infect 2017
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Figure 1: Hand touch frequency and gross microbial soil for five near patient sites on ICU

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**How do we measure hospital cleaning?**

Fluorescent gel placed on chosen sites
After patient discharge, a site is considered cleaned if the fluorescent material is removed or disrupted

*Carling et al, Am J Infect Control, 2006*

Removal of marker may not correlate with cleaning of alternate sites on the same surface

*Sitzlar et al, ICHE 2013*
What’s the long term effect?

- Maintenance of environmental services cleaning and disinfection in the ICU after a performance improvement project
  
  Fitzgerald et al, AmJIC 2012

How do we measure hospital cleanliness?

- 82-91% Visually clean
- 10-24% ATP clean
- 30-45% Microbiologically clean

What is clean?

“what an individual thinks it is”

Griffith CJ et al, J Hosp Infect 2000
Surface evaluation using ATP bioluminescence

Swab surface → luciferase tagging of ATP → Luminometer

Used in the commercial food preparation industry to evaluate surface cleaning and as an educational tool for more than 30 years

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<table>
<thead>
<tr>
<th>Site</th>
<th>Before*</th>
<th>After*</th>
<th>Site Mean ATP Before</th>
<th>Site Mean ATP After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locker (M)</td>
<td>15-316</td>
<td>17-148</td>
<td>120</td>
<td>69</td>
</tr>
<tr>
<td>Locker (S)</td>
<td>7-325</td>
<td>5-288</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L Bed (M)</td>
<td>4-243</td>
<td>4-1512</td>
<td>105</td>
<td>131</td>
</tr>
<tr>
<td>L Bed (S)</td>
<td>4-181</td>
<td>32-115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O/B Table (M)</td>
<td>28-625</td>
<td>13-75</td>
<td>181</td>
<td>309</td>
</tr>
<tr>
<td>O/B Table (S)</td>
<td>33-550</td>
<td>55-3846</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R Bed (M)</td>
<td>3-409</td>
<td>3-200</td>
<td>132</td>
<td>57</td>
</tr>
<tr>
<td>R Bed (S)</td>
<td>0-266</td>
<td>16-128</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Benchmark = 100 RLU’s

Mulvey et al, J Hosp Infect 2011
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What effect does ATP monitoring have?

Study in 2 ICUs in a public 1800-bed hospital in Taiwan

Cleaning efficacy was monitored by ATP bioluminescence after cleaning; <45% of 221 surfaces passed

After a new cleaning protocol, 88% of 270 surfaces were clean according to ATP criteria. Combined HAI rates in the ICUs apparently decreased by half!

ATP systems encourage cleaning effectiveness, but they do not necessarily measure surface cleanliness. High ATP values do not necessarily mean presence of microbial pathogens!


Would microbiological standards help?

5 cfu/cm² 45 cfu/cm²

Slide from Chris Griffith

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Microbiological standards for surface hygiene in hospitals

**Standard 1**

*There should be* 1<sub>cfu/cm</sub><sup>2</sup> *pathogen (MRSA; C.difficile; VRE; etc) on healthcare surfaces*

**Standard 2**

*Aerobic Colony Count (ACC) or total microbial growth level from a hand touch surface should be* 5<sub>cfu/cm</sub><sup>2</sup>

These standards are based upon food industry counts as applied to food preparation surfaces but could be utilised for frequent hand touch surfaces in hospitals

*Dancer S, J Hosp Infect 2004*
So which is the best method for measuring how clean a hospital is?

*Aim for a system which shows measurable benefit for patients: aesthetics, cleaning focus, cleaner surfaces, and if you’re lucky, HAI rates; but… wouldn’t it be nice to have a system that gives us early warning of an imminent outbreak?*

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**Correlating cleaning effect against surface cleanliness indicators**

- **Fluorescent marker vs ACCs:** how well have surfaces been cleaned
- **Fluorescent marker vs ATP:** which surfaces need cleaning

*Boyce et al, ICHE 2011*
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**Correlating cleaning effect against surface cleanliness indicators**

![Graph showing correlation between cleaning effect and surface cleanliness indicators](image)

- **Fluorescent marker vs ACCs:** How well have surfaces been cleaned?
- **Fluorescent marker vs ATP:** Which surfaces need cleaning?

**What is the evidence for cleaning as a viable control mechanism for hospital-acquired infections?**

Two matched wards received one extra cleaner (Monday to Friday), with each ward receiving enhanced cleaning for six months in a cross-over design;

Enhanced cleaning led to a 33% reduction in levels of microbial soil at hand-touch sites; and 27% reduction in new MRSA infections, despite higher bed occupancies and MRSA colonisation pressures (p=0.032: 95% CI 7.7%, 92.3%).

**BBC website, 2008**

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**Total aerobic colony counts (ACC) from hand-touch sites on two matched wards; the cleaner moved from Ward A to Ward B at week 26**

![Graph showing total ACC (cfu/cm²) over weeks for Ward A and Ward B, with peaks and troughs indicating changes in ACC.]

*Graph Source: Dancer et al, BMC Med, 2009*

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**Keep your cleaning staff in-house!**

![Graph showing MRSA Incidence rate by type of cleaning service in 2010.]

*Graph Source: Toffolutti et al, Social Science & Medicine 2017; 174: 64–69*

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Notes: Source: Data from Hospital data from Patient Environment Action Teams (PEAT) dataset (2010), and Public Health for England (2010). Red dashed line represents the density for Trusts which contracted-out their cleaning services, blue solid line represents the density for in-house delivered cleaning services.

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Wiping Out Clostridium difficile

Clostridium difficile infection incidence for units A and B combined, before and after the intervention

HAI, hospital-acquired CDAD; INC, overall CDAD incidence; PD, patient days; PT, patient.

Orenstein et al, ICHE 2011

Basic hygiene measures reduced VRE incidence

Figure 1. Daily percentage of patients colonized with vancomycin-resistant enterococci (VRE), daily acquisition of rectal colonization with VRE, and mean percentage of patients colonized with VRE, by period. Period 1 was a baseline period (1 March–1 May 2001), duration, 45 days. Period 2 included environmental hygiene intervention (1 May–27 July 2001), duration, 59 days. Period 3 was a “washout” period in which there was no intervention (23 August–18 October 2001). duration, 57 days). Period 4 included hand hygiene intervention (18 November–7 February 2002), duration 87 days.

Hayden et al CID 2005

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The Hand-Touch equation:

Hand-touch site

...is equal and opposite

Dancer SJ, ICHE 2010

Impact of a Hand-Hygiene Intervention on Contamination of Patient’s Hands with Healthcare-Associated Pathogens

One surprising finding was that patient hand hygiene was associated with reduced contamination of environmental surfaces............

Sunkesula et al, ICHE 2016
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Daily cleaning?

Contact plates from patient locker surface
Left to right: Pre clean, 1 hour, 2 hour, 3 hour assessment

How long do hospital surfaces stay ‘clean’?

MRSA rapidly recontaminates high-touch sites in ICU after H202 vapour
Hardy KJ et al, JHI 2007

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Effect of detergent (blue line) and disinfectant (red line) cleaning on total ACC at hand-touch sites over 48 hours

Stewart et al, ICHE 2014

Effect of detergent and disinfectant cleaning on total MSSA/MRSA at hand-touch sites on one 30 bed ward over 48 hours

Stewart et al, ICHE 2014

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Do biofilms on hospital surfaces protect viable pathogens from cleaning?

Vickery et al, J Hosp Infect 2015

New disinfectants on the Block

‘Chemzyme Plus’
A soup of Bacillus subtilis
A disinfectant containing good bacteria reduced ‘bad’ bacteria by 1,000-fold compared with standard cleaning
http://chemexuk.com

Phage disinfectants
Bacteriophages that target hospital pathogens can be incorporated into disinfectants
http://www.phageworks.com

Neutral Electrolysed water
Normal tap water with added salt that has had an electric current passed through it

Meakin N et al, J Hosp Infect 2012

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Electrolysed water

What is it?

Electrolysed water is normal tap water with added salt exposed to an electric current. Non-toxic!

It is microbiocidal due to the presence of hypochlorous acid. This acid is only present in very low concentrations so that the product has a neutral pH, the same as ordinary water.

How good a disinfectant is it? Is it better than bleach?

Also effective for decontaminating sensitive clinical equipment

Meakin N et al, JHI 2012; Dancer et al, Healthcare Infection 2015

Cold Plasma Technology reduces surface bacterial counts

Multiple-jet air decontamination of patient tray tables over 8 weeks (n= 6; NS, non significant; *P< .05).

Claro et al, Infect Control Hosp Epidemiol 2017
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Effect of bleach vs steam against *E.coli* biofilm

- **A** 10 ppm NaClO
- **B** Steam

<1 second steam achieves better disinfection than 10 ppm sodium hypochlorite for 10-20 minutes

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**Antimicrobial surfaces**

- Copper (toilet seats, sinks, handles, etc)
- Silver (textiles, etc)
- Triclosan (toothpaste, chopping boards, etc)
- Paints containing polyurethanes, epoxy materials, styrene acrylcs
- Polymer ‘conjugated poly-electrolyte’ plus fluorescent light
- Nanocoating (nanotubes plus lysostaphin)

‘...antimicrobial coatings must not undermine traditional hygiene methods and neither should conventional cleaning be relaxed if antimicrobial coatings are employed’

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Failure of copper-based NanoCote/Aqua-Based antimicrobial paint in a hospital setting

Laminated wood bedside table coated with NanoCote HD-WR (before curing). Close-up view showing uneven distribution after application


‘Oak in hospitals, the Worst Enemy of Staphylococcus aureus?’

Potential antimicrobial activity of oak (Querceus spp.) was tested against a panel of S. aureus isolates

Four MSSA and four MRSA; Two different orientations of oak used

Oak showed antimicrobial activity towards all the isolates tested; BUT… diameter of the wooden discs was 9mm, as opposed to 2mm for a standard antibiotic disc

Pailhoriès et al, ICHE 2016

Disinfect everything…..

Dancer SJ, Clin Micro Rev 2014;
Po & Carling, ICHE 2010

Does $H_2O_2$ improve disinfection of ICU rooms?

Prospective crossover study in a French hospital; rooms were cleaned with quat & sodium hypochlorite, followed by either $H_2O_2$ vapour or aerosolized $H_2O_2$ combined with peracetic acid;

BEFORE any $H_2O_2$ disinfection, only 23 (1.5%) of 1,456 sampled surfaces and 15 (8%) of 182 rooms were MDRO-positive after patient discharge;

$H_2O_2$ disinfection reduced ESBLs only, since no other MDROs were found after routine cleaning;

These ESBLs were found mostly from sinks..

Blazejewski C et al, Crit Care 2015

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Terminal decontamination of rooms using H2O2 vapour

Patients were 64% less likely to acquire MDROs and 80% less likely to acquire VRE ($P < 0.001$) following H$_2$O$_2$ terminal cleaning……..

But the risk of acquiring Clostridium difficile, MRSA and multidrug-resistant Gram-negative bacilli was ‘not significantly reduced’;

The significance quoted for the overall result came from the VRE data only.


An Environmental Disinfection Odyssey: evaluation of sequential interventions to improve disinfection of C.difficile isolation rooms

35% of rooms remained culture positive for C. difficile after use of UV devices

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The effect of distance on the efficacy of the PX-UV device

Nerandzic et al, ICHE 2015

Incidence of MDROs and Clostridium difficile from January 2009 until April 2013; pulsed UV light introduced May 2011

Haas J et al, AmJIC 2014

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Incidence of MDROs and *Clostridium difficile* from January 2009 until April 2013; pulsed UV light introduced May 2011

*Haas J et al, AmJIC 2014*

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Hydrogen peroxide can’t penetrate linen, pillows or soft furnishings

Can UVC waves go round corners?
That’s a NO, then?
Toxicity?

- Humans
- Surfaces
- Plastics
- Plants
- Animals

Time taken for decontamination

- Need to remove the patient;
- Need to totally seal off a room before H2O2 exposure;
- Need to reposition UVC apparatus for uniform coverage;
- Need to train staff;
- Need to prepare room;
- Need to remove soft furnishings;
- Can’t do open plan....
The H202 robot system costs about US $40,000; the UV light system costs more than US $100,000.

..is current evidence on clinical benefit sufficiently plentiful, and indeed, robust, to allocate scarce healthcare resources for these systems? ‘Dancer SJ, Floor Wars letter, JHI 2013

Aggressive marketing by robot companies encourages healthcare managers to choose these methods...

...but no one knows whether plain old soap and water might actually do the job just as well, for much less cost and minimal effect on people and environment
Man-agers are more likely to choose push-button gadgets rather than reduce bed occupancy or engage more cleaners

Boys with toys?
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The efficacy of any cleaning/disinfectant agent tested is dependent on physical action.

Even if all the rooms are decontaminated by robots, we still need staff to manually pick up litter...
**Time to get PHYSICAL!**

*C. difficile* and cleaning – alternative options to using chlorine-releasing disinfectants……..could *C. difficile* be removed by routine physical cleaning?


A single clean can reduce contamination by around 90%…..


Detergent gives the same result as disinfectant for cleaning clinical equipment

Petti et al, *AmJIC* 2012

When surfaces are wiped 3 or more times, detergent wipes are *just as effective* as disinfectant wipes

Berendt et al, *AmJIC* 2011

*Physical removal of C. difficile spores is more important than sporicidal inactivation*  

Rutala et al, *ICHE* 2012

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**CONCLUSION**

**DO** value traditional cleaning

**DO** monitor cleaners; cleaning; or what is left behind (however you like)

**DO** keep your cleaners in-house!

**Don’t** prioritise hand hygiene over cleaning

**Don’t** waste money on robots or antimicrobial paint

**Don’t** believe everything that salesmen tell you!
NB. No disclosures
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